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Monitoring the water vapor isotopic composition in the temperate North Atlantic

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Water stable isotopes have during many decades been used as climate proxies and indicators for variations in the hydrological cycle. However we are to a great extent still using simple empirical relationships without any deeper theoretical understanding. In order to properly relate changes in the climate and hydrological cycle to changes in the observed stable water isotopic signal we must understand the underlying physical processes. Furthermore it is a challenge for General Climate Models to adequately represent the isotopes in the hydrological cycle because of lack of in-situ measurements of the atmospheric water-vapor composition in the source regions.

During the fall of 2010 we installed an autonomous water vapor spectroscopy laser (from Los Gatos Research) in a lighthouse on the South Coast of Iceland (63.83 N 21.47W) with the plan to be operational for several years. The purpose of this installation was through monitoring of the water vapor isotopic composition to understand the physical processes governing the isotopic composition of the water vapor evaporated from the ocean as well as the processes of mixing between the free troposphere and marine boundary layer.

Because of the remoteness of the monitoring site and simple topography we are able to isolate the 'fingerprint' on the isotopic signal in the water vapor from respectively the ocean and the interior highland leading to a near perfect case-study area.

Using back-trajectories we find a strong influence of the origin of the air masses on the measured isotopic composition. The mixing of the marine-boundary layer is found to strongly influence the measured isotopic composition. The second order isotopic parameter, d-excess, is contrary to theory and previous observations found not to depend on the relative humidity. However we do find a good correlation between the d-excess and the measured isotopic composition. We speculate that the lack of correlation between d-excess and relative humidity can be caused by a strongly varying d-excess signal of the free troposphere. This opens up for the possibility to use the measured isotopic composition in the lower part of the boundary layer as indicator for the isotopic composition of the free troposphere.

The site likely represents a major source region for the moisture that later falls as snow on parts of the Greenland Ice Sheet. This leads to a better understanding of the processes, which create the climatic signal in the water isotopic signal found in ice cores drilled on the ice sheet.